Claims

1. Switching device for bidirectionally equalizing charge between energy accumulators (6, 7), especially between capacitive energy accumulators (6, 7) in a motor vehicle electrical system (1) with integrated starter-generator (2),
with a first terminal (22) which is coupled to the starter-generator (2),
with a second terminal (23), which is coupled to an energy source (6, 7),
with a controllable transfer gate (29) which features a load current carrying path arranged between the first and second terminal (22, 23),
with a controllable switching controller (21) which features a second load current carrying path, arranged between the first and second terminal (22, 23) and parallel to the first load current carrying path.

2. Switching device in accordance with claim 1, characterized in that the switching controller (21) is embodied as a downward controller.

3. Switching device in accordance with one of the previous claims, characterized in that, the switching controller (21) features at least two

controllable first switches (27, 28), which with regard to their controlled links, are arranged in series, with an inductive energy accumulator (24) being arranged between a relevant first load connection (S) of the first switch (27, 28) and being connected in each case to a relevant terminal of the inductive energy accumulator (24) via a free-wheeling diode (25, 26) to a supply connection (39) for a supply potential (GND).

4. Switching device in accordance with claim 3,
c h a r a c t e r i z e d i n t h a t
the first switches (27, 28) are embodied as current-sensing transistors, especially as sense MOSFETs.

5. Switching device in accordance with one of the previous claims,
c h a r a c t e r i z e d i n t h a t
the transfer gate (29) contains a parallel circuit comprising controllable second switches (T1 - T6), with two of the second switches (T1 - T6) in each case, as regards their controlled links, being arranged in series and defining a load path in each case, with the control terminals (G) of the second switch (T1 - T6) being connected to each other with first load connections (S) of the second switch (T1 - T6) being connected to each other and with second load connections (D) of the

second switches (T1 - T6) being connected either to the first terminal (22) or the second terminal (23).

6. Switching device in accordance with one of the claims 3 to 5,
characterized in that
the first and/or the second switches (27, 28; T1 - T6) are embodied as power switches, especially as power MOSFETs, especially as n-channel power MOSFETs.

7. Switching device in accordance with one of the claims 3 to 6,
characterized in that
the first load terminals (S) of the first and/or the second switches (27, 28; T1 - T6) are embodied as source terminals (S) and their second load terminals (D) as drain terminals (D).

8. Switching device in accordance with one of the claims 5 to 7,
characterized in that
the transfer gate (29) features a gate protection circuit (40), which is arranged between the control terminals (G) and the first load terminals (S) of the second switches (T1 - T6) and which protects the control terminals (G) of the second switches (T1 - T6) from an overvoltage.

9. Switching device in accordance with one of the claims 5 to 8,

c h a r a c t e r i z e d i n t h a t

the transfer gate (29) features a switch-off device (43), which, to switch off the transfer gate (29) short circuits the control terminals (G) and the first load terminals (S) of the second switches (T1 - T6) and thus switches off the second switches (T1 – T6).

10. Switching device in accordance with one of the claims 5 to 9,

c h a r a c t e r i z e d i n t h a t

for activation of the second switches (T1 - T6) a switchable oscillator (42), especially a Schmitt trigger circuit (42), is provided, downstream of which a charge pump (41) is connected which activates the control terminals (G) of the second switches (T1 - T6) with a control signal.

11. Switching device in accordance with one of the claims 5 to 10,

c h a r a c t e r i z e d i n t h a t

at least one current sensing device (35, 36) is provided, which is connected to at least one of the first switches (27, 28) which taps off a signal (KS11, KS22; CS11, CS22) derived from

the current (T1) through the load path of the relevant first switch (27, 28) and which, as s function of this, provides a current sensing signal (CS1 CS2) at the output of the current sensing device (35, 36).

12. Switching device in accordance with one of the previous claims,
c h a r a c t e r i z e d i n t h a t
a scheduling circuit is provided (36) which controls the function of the switching controller (21) and of the transfer gate (29).

13. Switching device in accordance with claim 12,
c h a r a c t e r i z e d i n t h a t
at least one gate control circuit (30, 31) is provided, which is connected on the input side to the scheduler circuit (36) and which, depending on a control signal (Ctrl1, Ctrl2) of the scheduler circuit (36) activates the control connection (S) of at least a first switch (27, 28).

14. Switching device in accordance with claim 13,
c h a r a c t e r i z e d i n t h a t
at least one auxiliary voltage source (32, 33) is provided, which is connected on the input side to a relevant first or second terminal (22, 23), which is arranged between a first

supply connection (39) with a first supply potential (GND) and a second supply connection with an second supply potential (5V) and which provides an auxiliary supply potential (Vaux1, Vaux2) for supplying the gate control circuit (30, 31).

15. Switching device in accordance with one of the previous claims,
c h a r a c t e r i z e d in t h a t
a voltage sensing device (37) is provided, which is coupled on the input side to the first and the second terminal (22, 23), which senses a differential voltage (Vdiff) present between the terminals (22, 23) and provides a signal (Vdiff1, Vdiff2) derived from this on the output side.

16. Switching device in accordance with claim 15,
c h a r a c t e r i z e d in t h a t
the voltage sensing device (37) features a first output (83) at which a signal (Vdiff2) derived from the amount of the measured differential voltage (Vdiff) can be tapped off, and which features a second output (84) at which a signal (Vdiff1) which can be derived from the leading sign of the measured differential voltage (Vdiff) can be tapped off.

17. Switching device in accordance with one of the claims 15 or 16,

c h a r a c t e r i z e d   i n   t h a t
the voltage sensing device (37) features a differential amplifier (80) on the input side which has a high common-mode rejection, to which the differential voltage (Vdiff) is coupled in on the input side, downstream of which a comparator (81) is connected which compares the output signal of the differential amplifier (80) with a reference potential (Vref).

18. Switching device in accordance with one of the claims 11 to 17,
c h a r a c t e r i z e d   i n   t h a t
The scheduler circuit (36) is connected on the input side to the output terminals (83, 84) of the voltage sensing device (37) and/or the current sensing device (35, 36) and evaluates the measured currents and voltages.

19. Switching device in accordance with one of the previous claims,
c h a r a c t e r i z e d   i n   t h a t
the switching device (20) is embodied as an integrated switching device (20).

20. Motor vehicle electrical system (1)
with at least two energy accumulators (6, 7),
with an integrated starter-generator (2),

which is linked mechanically to an internal combustion engine (3),
which, in generator mode, charges up at least one energy accumulator (6, 7) and
which, in motor mode, can be driven by the energy stored in at least one energy accumulator (6, 7),
with a bidirectionally operable AC/DC converter (4) arranged between the energy accumulators (6, 7) on the one side and the integrated starter-generator (2) on the other side, with at least one switching device (20) in accordance with one of the previous claims,
which is arranged between a DC terminal of the AC/DC converter (4) and at least one energy accumulator.

21. Motor vehicle electrical system in accordance with claim 20,
characterized in that
the energy accumulators (6, 7) are physically separated from one another in operation.

22. Motor vehicle electrical system in accordance with one of the claims 20 or 21,
characterized in that
at least one switching device (9, 10, 20) is provided for physical separation of the energy accumulators (6, 7).

23. Motor vehicle electrical system in accordance with one of the claims 20 - 22,
characterized in that
a first energy accumulator (7) is embodied as an accumulator (7) and a second energy accumulator (6) as a double-layer capacitor (6).

24. Motor vehicle electrical system in accordance with one of the claims 20 - 23,
characterized in that
the switching device (20) is arranged between the double-layer capacitor (6) and the DC terminal of the AC/DC converter (4).

25. Motor vehicle electrical system in accordance with one of the claims 20 - 24,
characterized in that
an intermediate circuit capacitor (5) for buffering a switched voltage is provided between the DC terminal of the AC/DC converter (4) and the at least one switching device (20).

26. Method for operating a switching device (20) in accordance with one of the claims 1 to 19,
with the following steps:
(a) first the switching controller (21) and the transfer gate

(29) are opened;
(b) a first potential (V1) at an input (22) of the switching device (20) is greater than a second potential (V2) at an output (23) of the switching device
(b) to close the switching device (20) a first control signal (On/Off) is applied to the device; (d) to reduce the differential voltage (Vdiff) falling via the switching device (20) the switching controller (21) is first operated in a switching controller mode;
(e) if the differential voltage (Vdiff) is largely balanced out, then the switching controller (21) is completely closed and the transfer gate (29) is switched on.

27. Method in accordance with claim 26,
characterized in that
the differential voltage (Vdiff) is measured and evaluated.

28. Method in accordance with one of the Claims 26 or 27,
characterized in that
on the basis of the measured differential voltage (Vdiff) a first voltage sensing signal (Vdiff2) as a measure of the amount of the differential voltage (Vdiff) and a second voltage sensing signal (Vdiff1) is created as a measure for the polarity of the differential voltage (Vdiff).

29. Method in accordance with one of the claims 26 - 28, characterized in that charge equalization between the output (23) and the input (22) is undertaken by operating the switching controller (22) in switching controller mode, provided the first voltage sensing signal (Vdiff2) exhibits a voltage difference (Vdiff2), which is greater than an upper threshold value.

30. Method in accordance with one of the claims 26 - 29, characterized in that the transistor (27) coupled to the input (22) is selected as the switching controller transistor (27) and the transistor (28) coupled with the output (23) is operated as statically switched on if the second voltage sensing signal (Vdiff1) displays a positive polarity of the differential voltage (Vdiff).

31. Method in accordance with one of the claims 26 - 30, characterized in that the steps (aa) to (ee) are performed iteratively in switching controller mode:

(aa) a load current (I1) through the controlled link of the transistor (27) connected to the input (22) and through the inductor (24) is measured;

(bb) the measured load current (I1) is monitored against an

upper limit value (Io);
(cc) the transistor (27) is switched off provided the load current (I1) has exceeded the upper limit value (Io);
(dd) the measured load current (I1) is monitored against a lower
limit value (I);
(ee) the transistor (27) will be switched back on if the charge current (I1) drops below the limit value (I).

32. Method in accordance with one of the claims 26 - 31,
characterized in that
the transistor (27) of the switching controller (21) connected to the input is permanently switched on and/or that the transfer gate (29) connected in parallel to the switching controller (21) is switched on provided the first voltage sensing signal (Vdiff2) exhibits a voltage difference (Vdiff2) which is less than a lower threshold value.

33. Method in accordance with one of the claims 26 - 32,
characterized in that
the transistor (27) of the switching controller (21) connected to the input is permanently switched on and/or that the transfer gate (29) connected in parallel to the switching controller (21) is switched on provided the charge time of the inductor (24) of the switching controller (21) falls below a

predetermined time limit value in switching controller mode.

34. Method in accordance with one of the claims 26 - 33, characterized in that on the basis of the measured differential voltage (Vdiff) the device detects when the differential voltage (Vdiff) is small enough or when the charge equalization between output (23) and input (22) has progressed far enough respectively to perform a permanent closure of the switching controller (21) and switch over to the transfer gate (29).

35. Method in accordance with one of the claims 26 - 34, characterized in that the circuit parts of the switching device (20) are monitored for their correct function and/or there is monitoring for errors in the functional sequence, and that, in the event of a detected error, the switching device (20) is not switched on.

36. Method in accordance with one of the claims 26 - 35, characterized in that the current switching state of the switching device is transferred in each case (20) by means of a status signal to an external control unit and is displayed there.

37. Use of a switching controller (21), especially of a

downward controller, for a controllable switch (20) for physically separating and switching an accumulator (7) and a double-layer capacitor (6) in a motor vehicle electrical system (1) with an integrated starter-generator (2).